ENVIRON

Proximate Modeling of Weekend Ozone - Results for Several Hypotheses and Years

February 20, 2001

Presented by

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Sponsors and Participants

- **Coordinating Research Council**
- **US DOE Office of Heavy Vehicle Technologies**
  Dr. Michael Gurevich, Program Manager
  - Funded through the National Renewable Energy Laboratory
- **Participants**
  - ENVIRON: Greg Yarwood, Ralph Morris, Till Stoeckenius
  - AIR: Jon Heuss, Jeremy Heiken

Presentation Outline

- **Recap of October 2001 Presentation**
- **New Results**
  - Friday Changes in MV Emissions and Carryover
  - Spatial Shift in MV Emissions
  - Aerosol Impact on Photolysis Rates
  - Weekend Effect in 1987 and 2010
  - SAPRC99 Chemical Mechanism
- **Summary**

October 2001 Presentation

- **Described methods, models and databases**
- **Results for NOx Mass and Timing Hypotheses**
  - looked at Saturday/Sunday changes in MV emissions for 1997
  - timing effect small compared to mass effect
  - modeled effects strikingly similar to observed effects for ozone and precursors

- http://www.arb.ca.gov/aqd/weekendeffect/weekendeffect.htm

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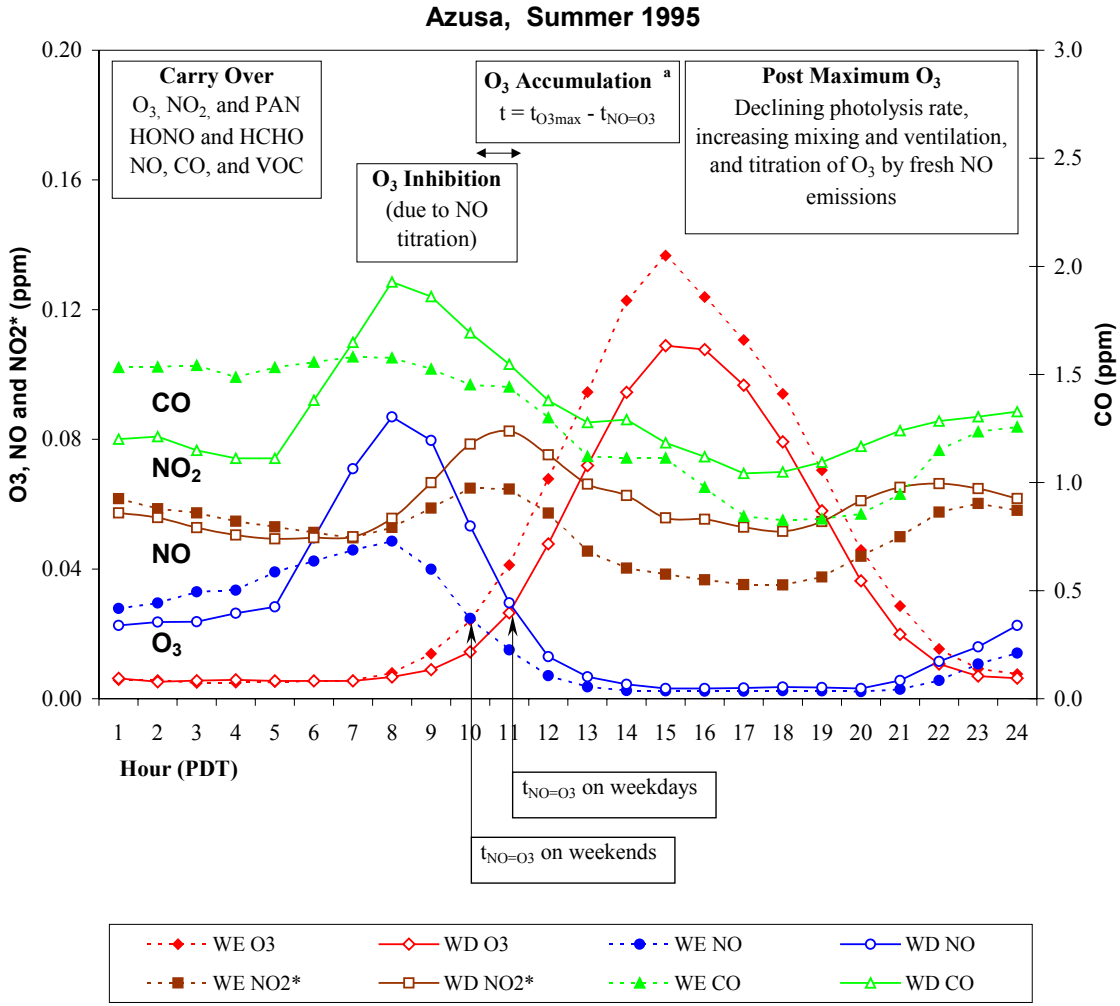
Observed WE Effect at Azusa for Comparison with Later Model Results



a. O3 accumulation rate = [O3(max) - O3 ($t_{NO=O3}$)]/(t_{O3max} - $t_{NO=O3}$)

*** Figure courtesy of Eric Fujita, DRI.**
http://www.arb.ca.gov/aqd/weekendeffect/nre1p1v1f.pdf

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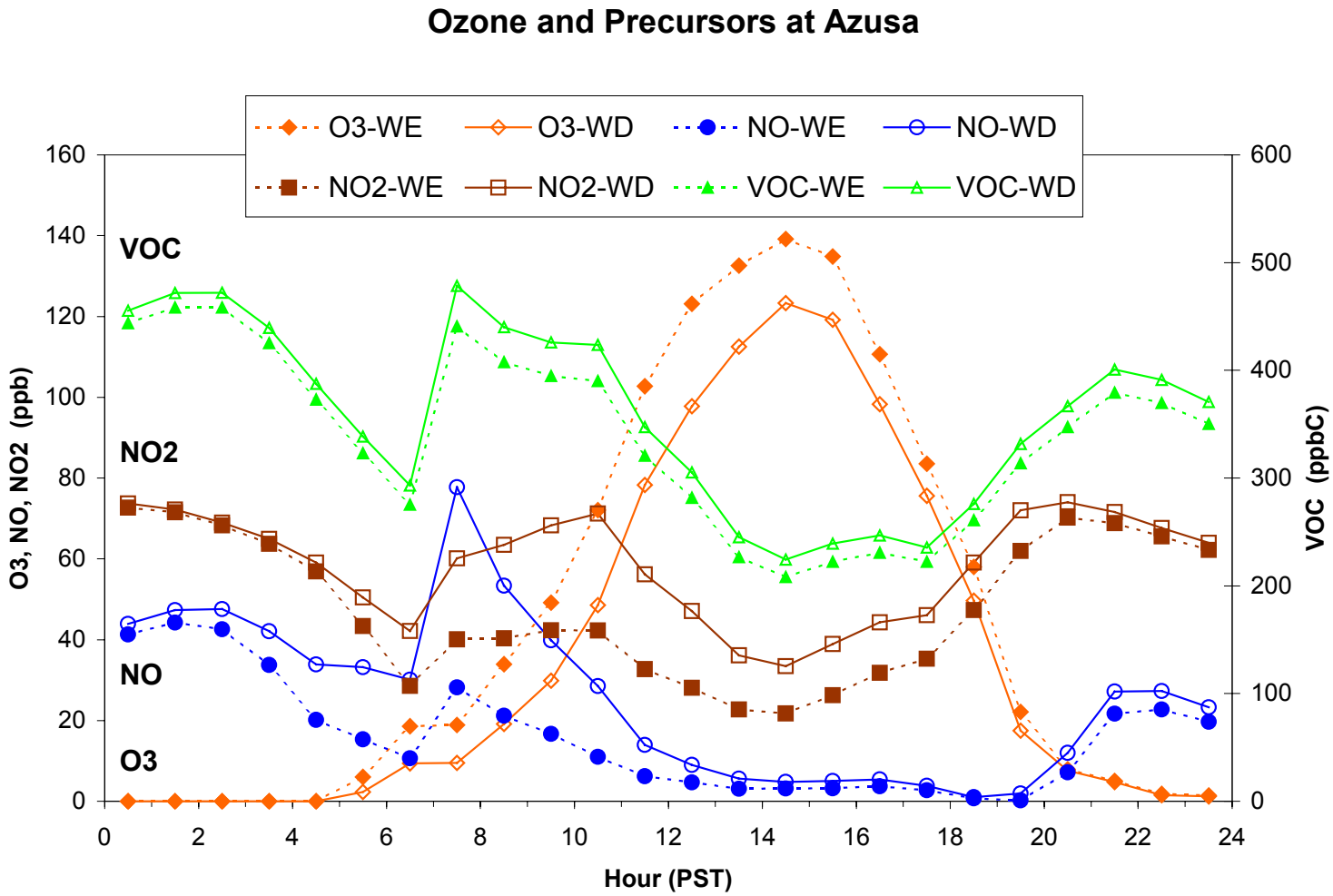
Azusa: Change Mass and Temporal Profile of MV Emissions



Model Run "Cheat Sheet"

Run Number	Description
wd_base	August 3-7, 1997 with every day as a weekday
wd_base_s99	wd_base using SAPRC99
h1a	change MV mass on Sat/Sun based on activity data
h1b	h1a using SAPRC99
h2a	change MV temporal profile on Sat/Sun based on activity data
h2c	change MV mass and temporal profile on Sat/Sun
h2d	h2c using SAPRC99
h2e	h3a plus h2f – change Fri/Sat/Sun MV mass/temporal/spatial
h2f	change MV spatial distribution on Fri/Sat/Sun
h3a	h2c plus Friday MV mass and temporal profile change
h3b	wd_base plus Friday MV mass and temporal profile change
h4a	h2c changing Sunday only
h5a	change photolysis rates on Sat/Sun to reflect lower aerosol load

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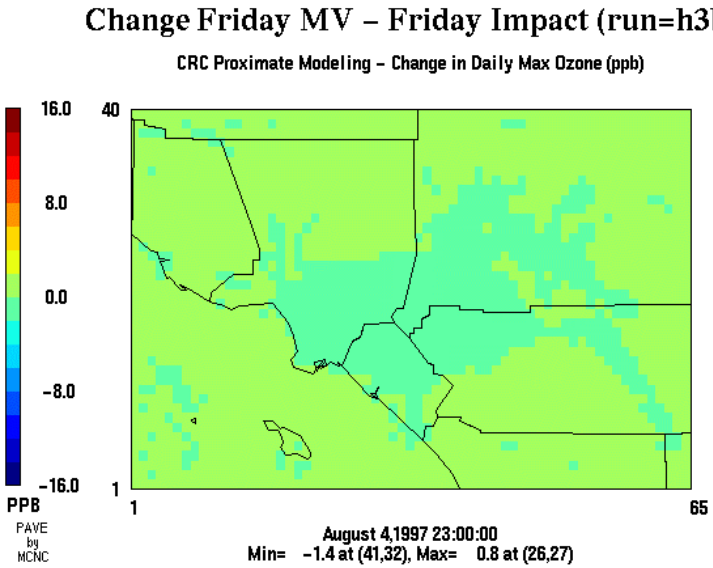
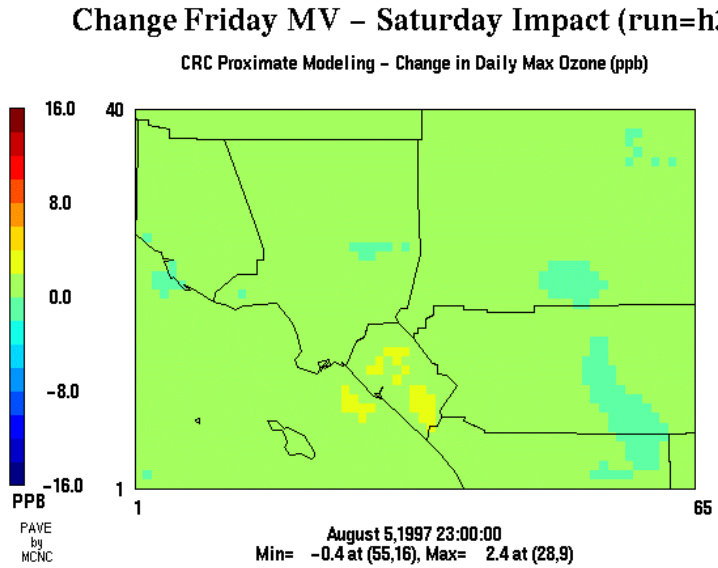
Friday Emission Change and Carryover

- Change mass and timing of Friday MV emissions based on activity data
- Little impact on daily maximum ozone on Friday or Saturday





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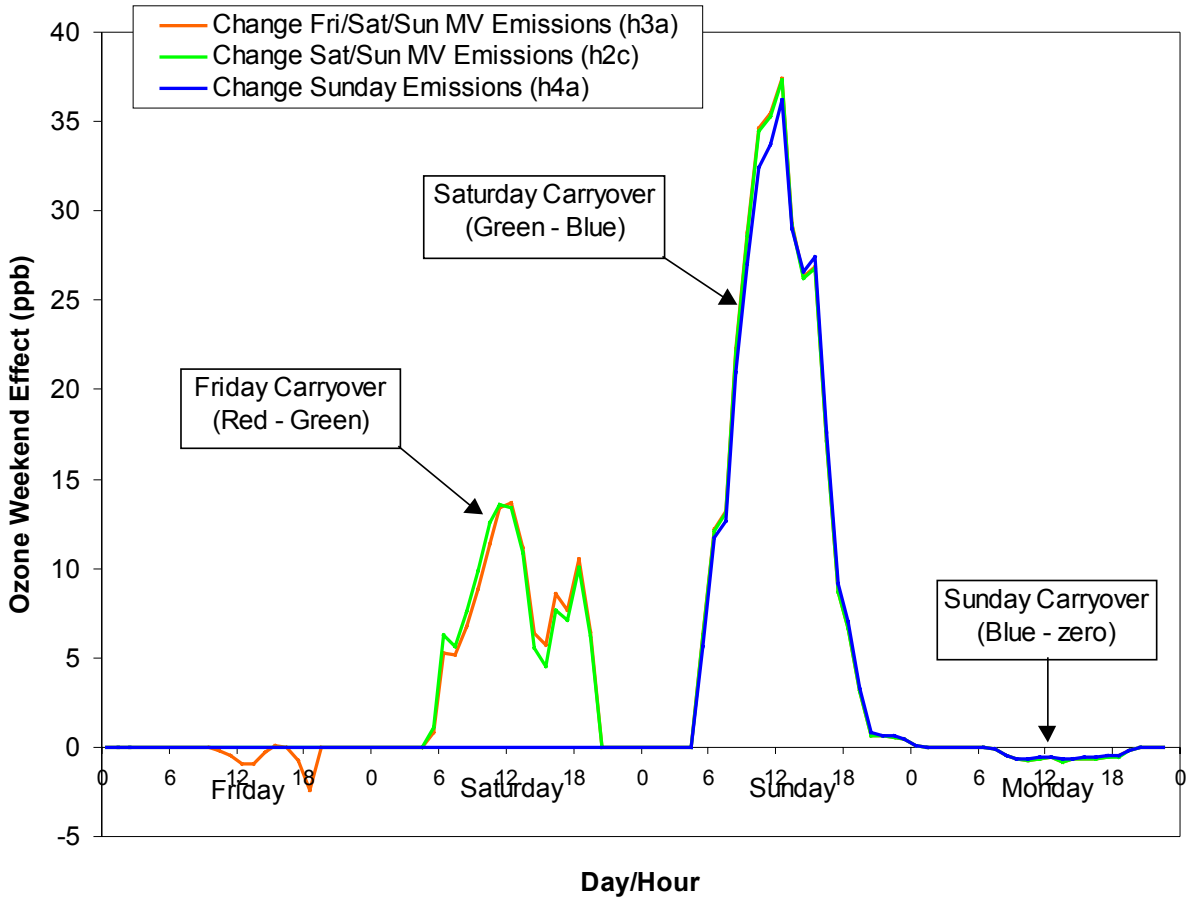
Friday through Monday Carryover at Azusa

- Carryover is small relative to same day effect of Saturday and Sunday emissions changes



Weekend Spatial Shift in MV Emissions

- **Hypothesis: less commute, more local driving on weekend**
- **Proximate representation**
  - NREL sponsored STI analysis of day of week differences in WIM data at 8 locations for LDV and HDV
  - ENVIRON gridded the differences by Kriging
  - Spatially shift the MV emissions while conserving total mass
- **Resulting spatial shift crudely approximates hypothesis**
- **Suitable for proximate modeling**
- **Not intended to represent reality**

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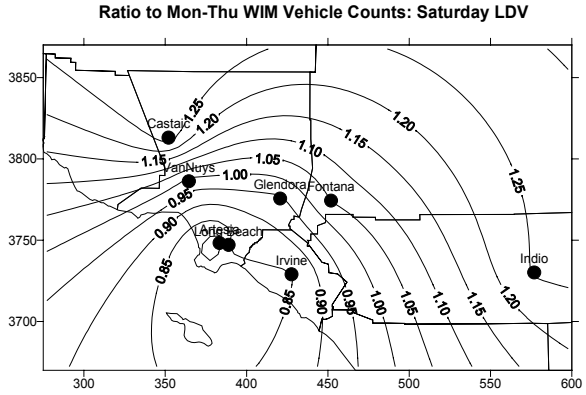
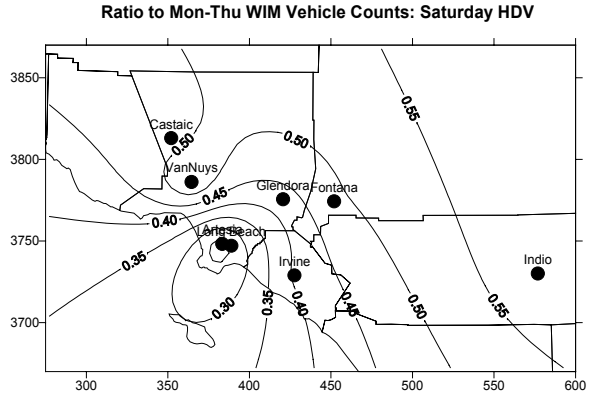
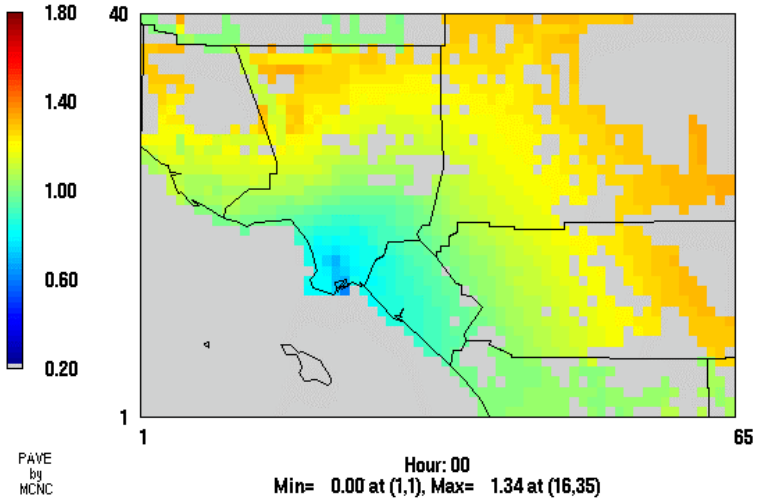
Saturday Emissions Shift





LDV

HDV



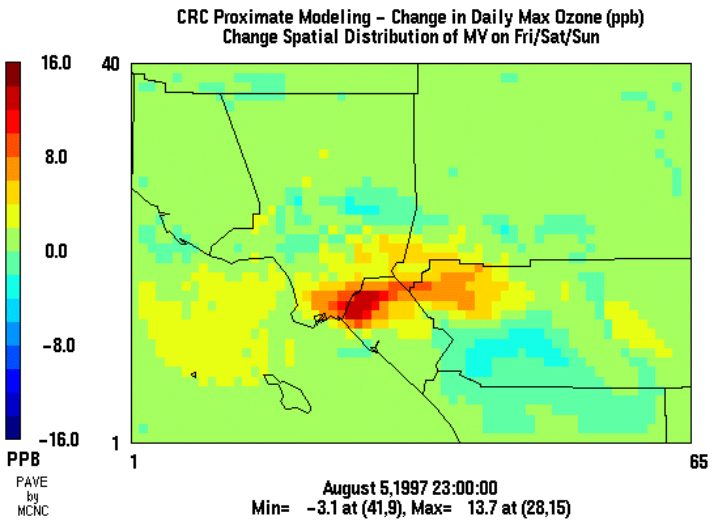
Grey areas have low or zero MV emissions

* Vehicle count data courtesy of Lyle Chinkin, STI

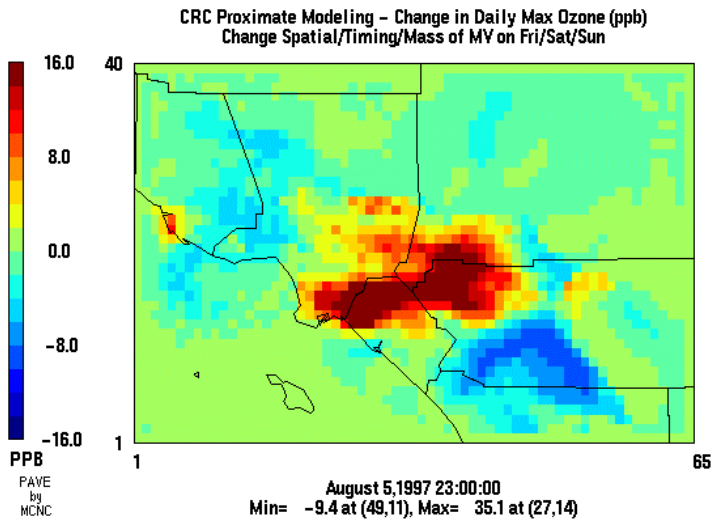
Saturday Effect of MV Emissions Shift

- Increases in daily maximum ozone through most of the basin
- Pattern of increases similar to MV mass/timing change
- Spatial shift and mass/timing changes are roughly additive

MV Spatial Shift – Saturday (run=h2f)



MV Spatial/Timing/Mass Change – Sat (run=h2e)



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Aerosol Impact on Photolysis Rates and Ozone

- **Hypothesis: lower aerosol load on weekend increases photolysis rates and accelerates ozone formation**
- **Measured optical depths due to aerosols at Riverside in summer 1997 were in range 1.0 to 0.2 at 340 nm: LLNL/UC Berkeley/Envair report for ARB (96-335)**
- **No data on WD/WE differences. Therefore, model the maximum range (0.2 to 1.0) to test sensitivity**
- **Changing CAMx Photolysis rates**
  - CAMx uses the TUV radiation model from NCAR
  - LLNL/UCB report for ARB also used TUV, but with less accurate numerics than CAMx uses ("2-stream" rather than "discrete ordinates")

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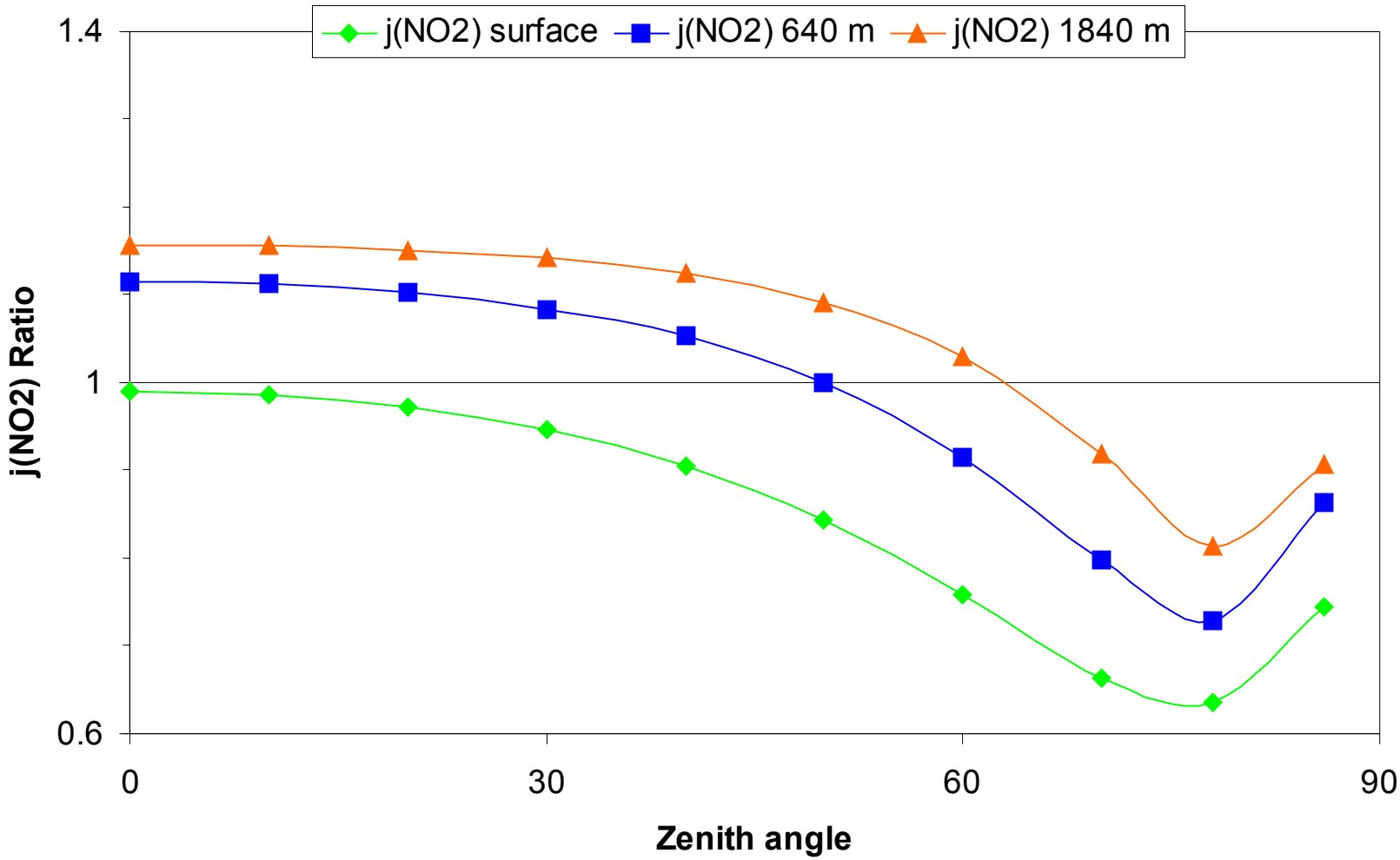
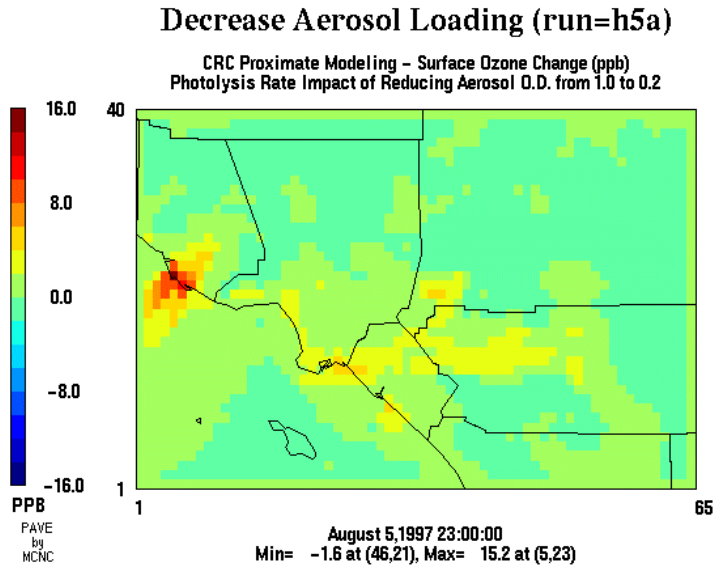
Photolysis Rate Sensitivity

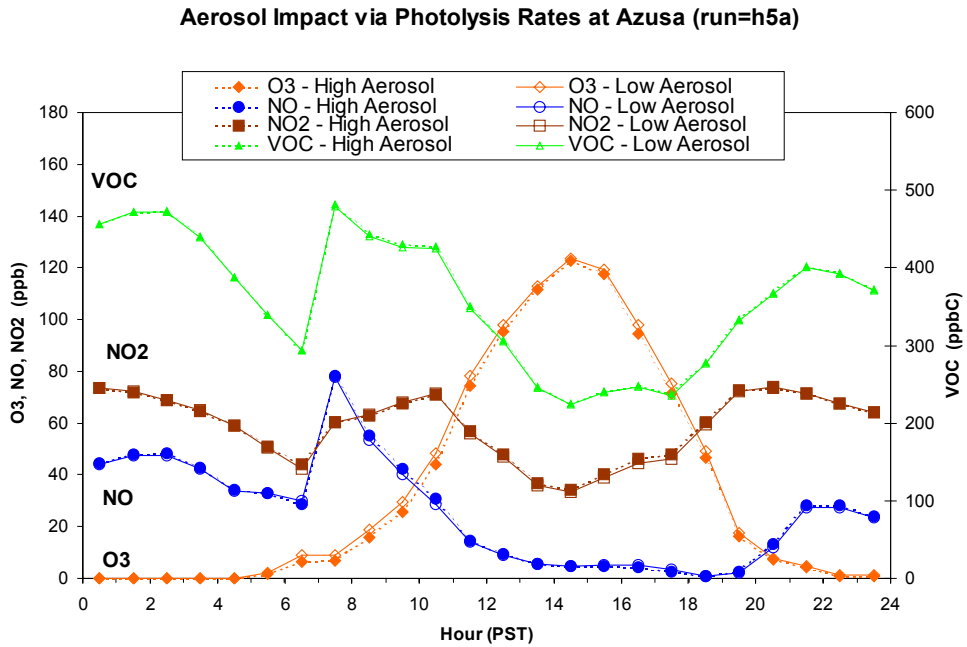
NO2 photolysis rate for an aerosol optical depth of 1.0 relative to 0.2



Air Quality Sensitivity to Aerosols

- **Results inconsistent with aerosols being important cause of weekend effect**
  - Almost no changes in precursor concentrations
  - Ozone changes too small and have wrong temporal profile





Weekend Effect in 1987 and 2010

- **Keep meteorology and biogenic emissions the same**
- **1987 anthropogenic emissions from ARB for Aug 28,1987**
- **2010 anthropogenic emissions from SCAQMD**
  - Based on August 28, 1987 SCAQS
  - EMFAC2000
  - Includes advanced technology controls (black box)
  - Consistency with ARB 87 and 97 emissions?
- **Model a weekday base case and Fri/Sat/Sun change to MV mass and temporal profiles**

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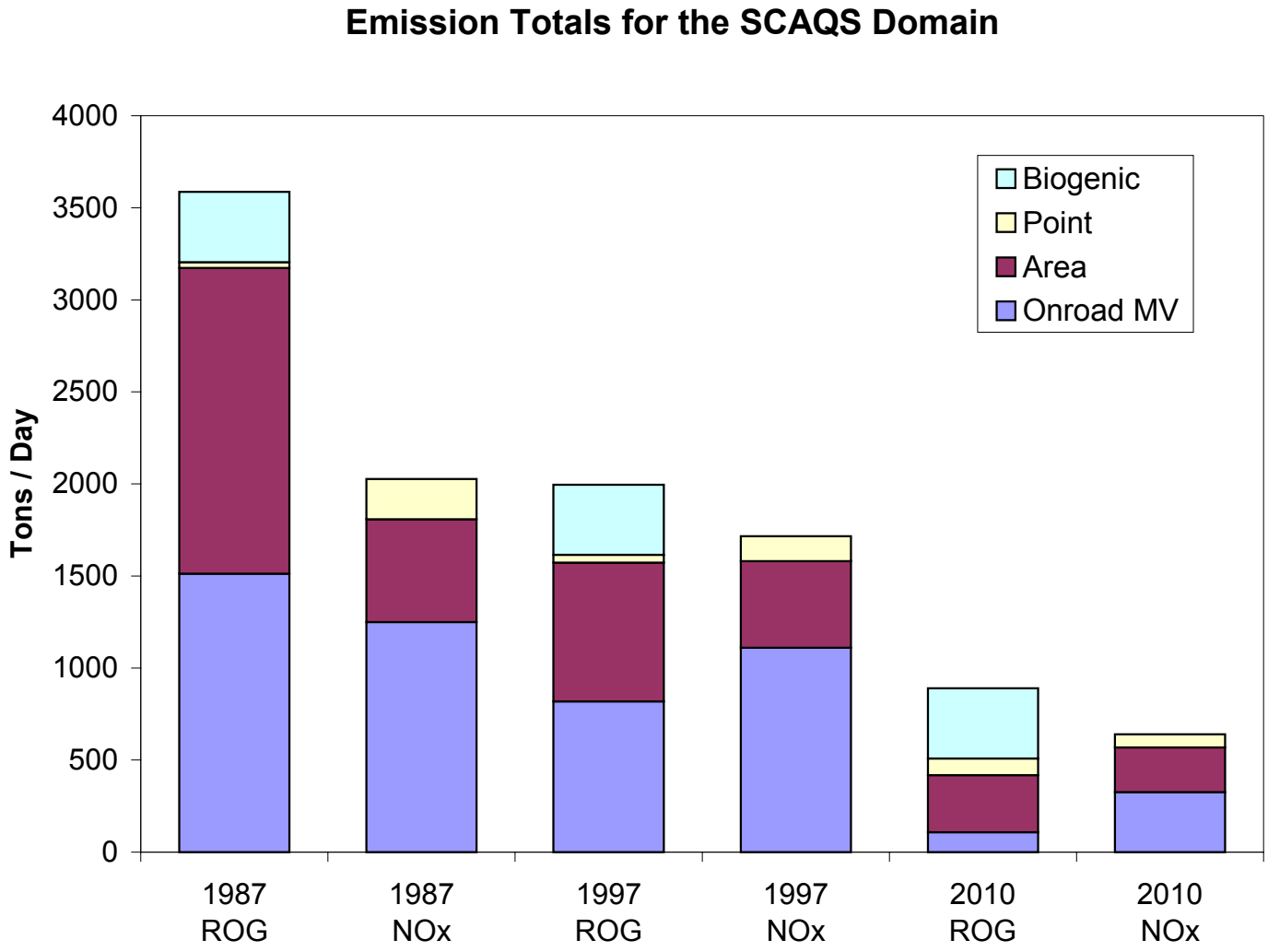
Emissions for 1987, 1997 and 2010



2010 Emissions Projections Are Uncertain

- **Future year inventories inherit uncertainties from base year inventories**
- **Future year emissions projections contain additional uncertainties from assumed activity growth and control strategy effectiveness**

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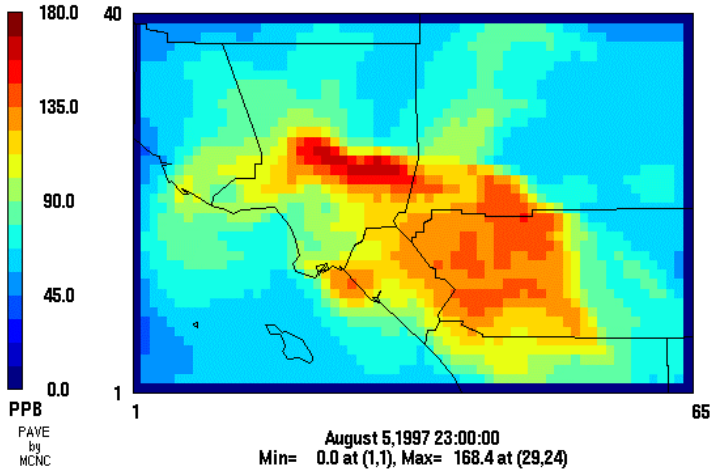
Peak Ozone for Aug 5 in 1987/1997/2010

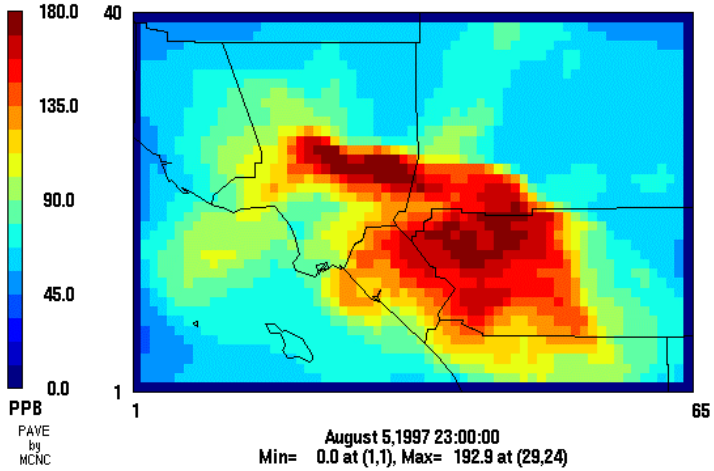
1997 Base Case (run=wd_base)

CRC Proximate Modeling – Daily Max Ozone (ppb)



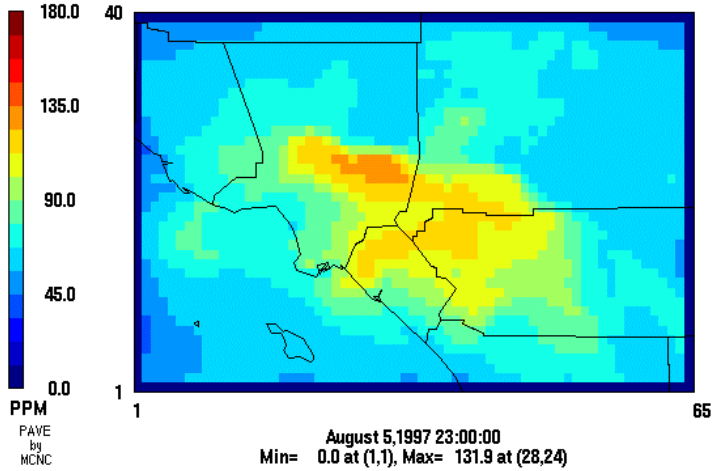
1987 Base Case (run=87_wd_base)

CRC Proximate Modeling – Daily Max Ozone (ppb)



2010 Base Case (run=10_wd_base)

CRC Proximate Modeling – Daily Max Ozone (ppb)



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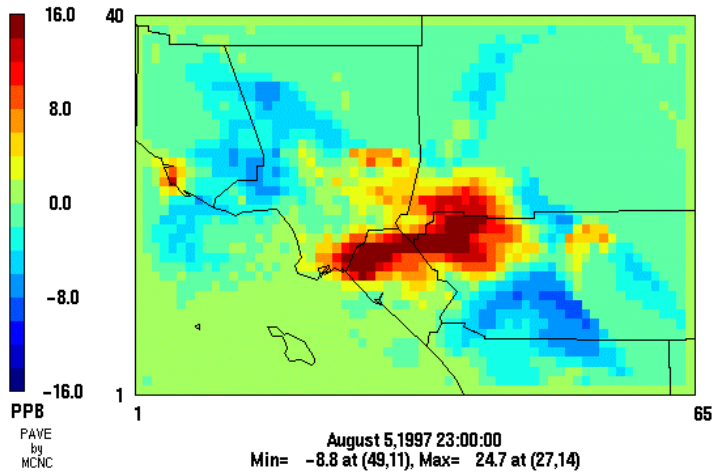
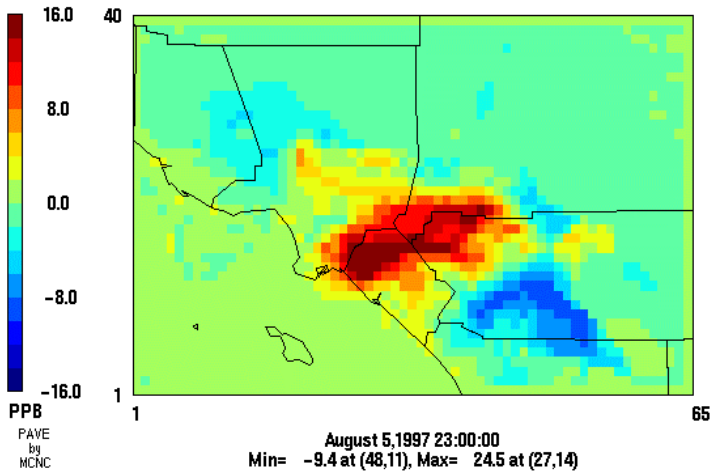
Saturday Effect on Ozone

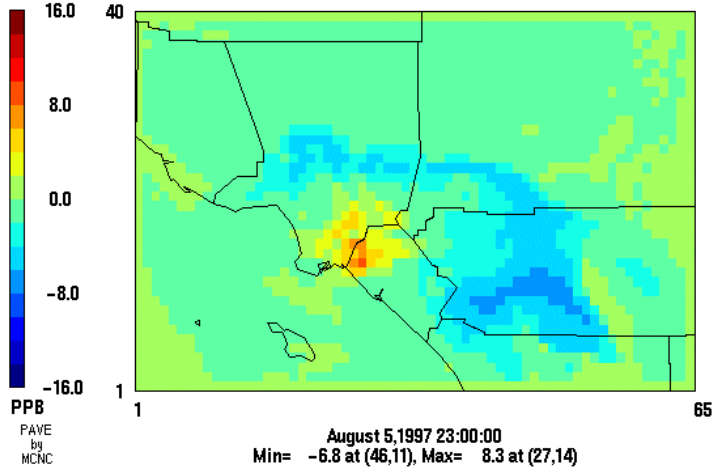
Change MV Mass & Temporal in 1997



Change MV Mass & Temporal in 1987



Change MV Mass & Temporal in 2010



Comparison Across Years

- 1987 has higher ozone than 1997 and generally similar weekend ozone effect
- 2010 has lower ozone than 1997
- 2010 weekend effect shows smaller area of weekend ozone increase and larger area of no change or decrease
- Results for 2010 are based on the emissions reductions included in the current Los Angeles AQMP

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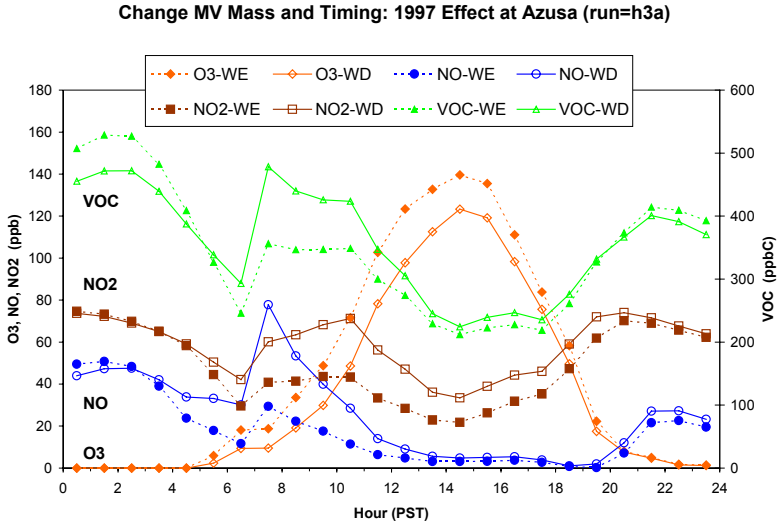
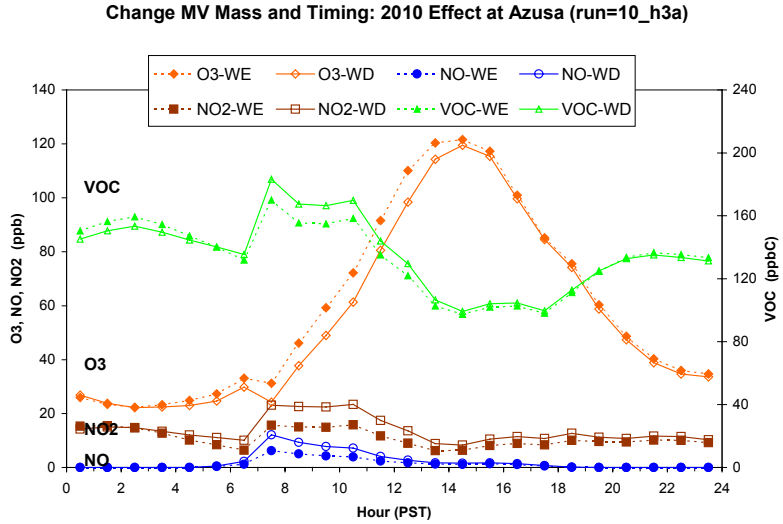
Effects at Azusa in 2010

- **Weekend ozone effect is smaller in 2010 than 1997**
- **2010 "signature" is similar to 1997**
  - higher morning VOC/NOx ratio on weekends
  - higher weekend ozone in morning through midday



1997



2010

SAPRC99 Mechanism Sensitivity

- **SAPRC99 mechanism in CAMx version 3.1**
  - fixed parameter version also used in CMAQ
- **ARB emissions available for SAPRC99 and CB4**
- **Impact on modeling results**
  - Model performance evaluation
  - Weekend effect for scenario h2c - change MV mass and temporal profiles for Sat/Sun in 1997

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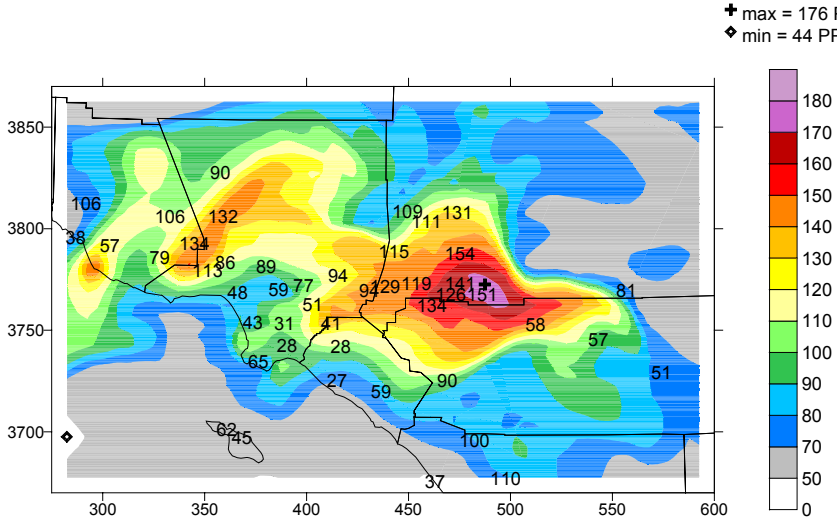
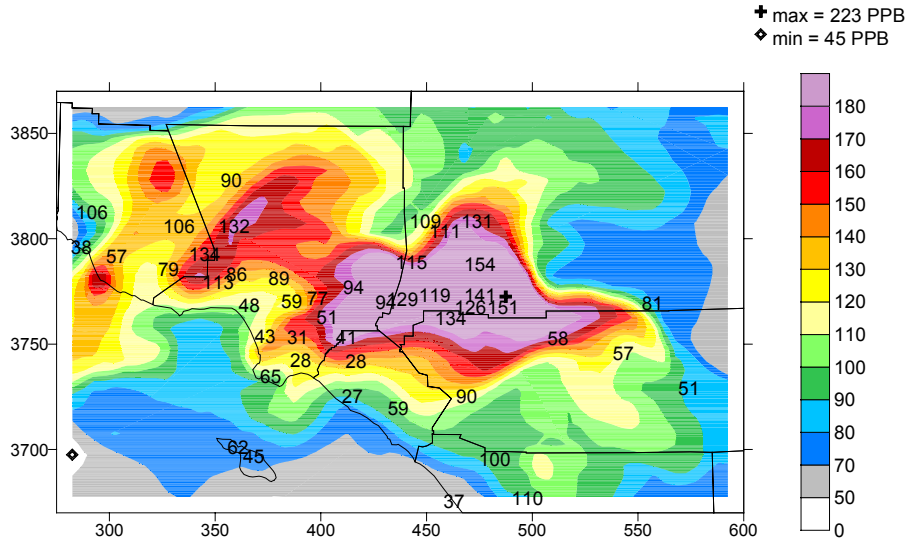
Higher Ozone with SAPRC99



CB4



SAPRC99

- **Daily maximum ozone for August 6, 1997. Other days show similar differences between CB4 and SAPRC99**

Poor Model Performance with SAPRC99

Comparison of CAMx/MM5 1-hour ozone model performance statistics with CB4 and SAPRC99 emissions. Gray shaded values fail the performance goal.

	EPA Goal	5-Aug	6-Aug	7-Aug
Observed Peak (ppb)		187	154	150
		CB4 Emissions		
Modeled Peak (ppb)		166.6	176.4	159
Unpaired Peak (%)	≤ ±20	-11	15	6
Normalized Bias (%)	≤ ±15	5	7	9
Normalized Error (%)	≤ 35	22	24	26
		SAPRC99 Emissions		
Modeled Peak (ppb)		203.9	223.0	200.4
Unpaired Peak (%)	≤ ±20	9	45	34
Normalized Bias (%)	≤ ±15	30	35	36
Normalized Error (%)	≤ 35	39	44	44

Statistical measures were calculated for valid data pairs with observed values > 60 ppb at 48 stations

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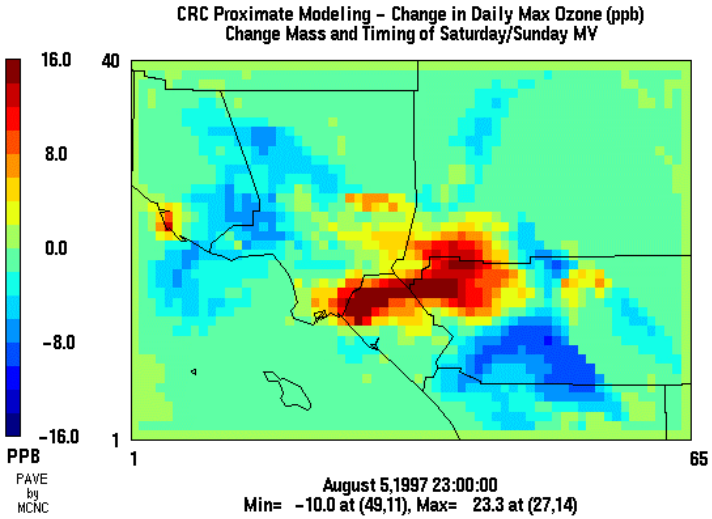
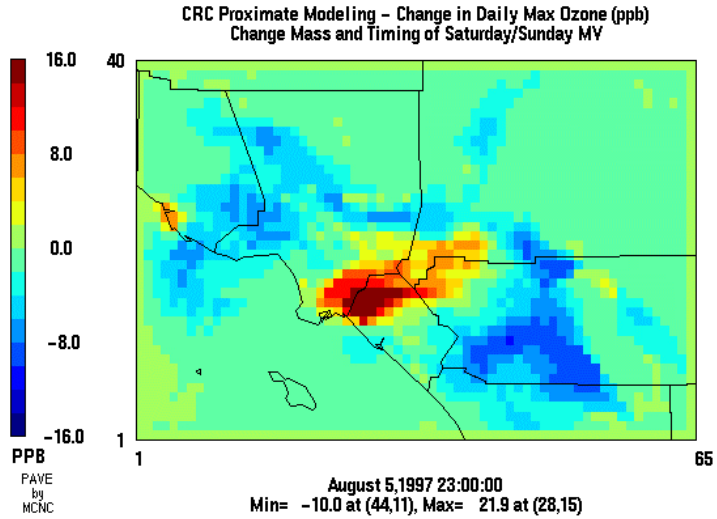
Weekend Effect with CB4 and SAPRC99

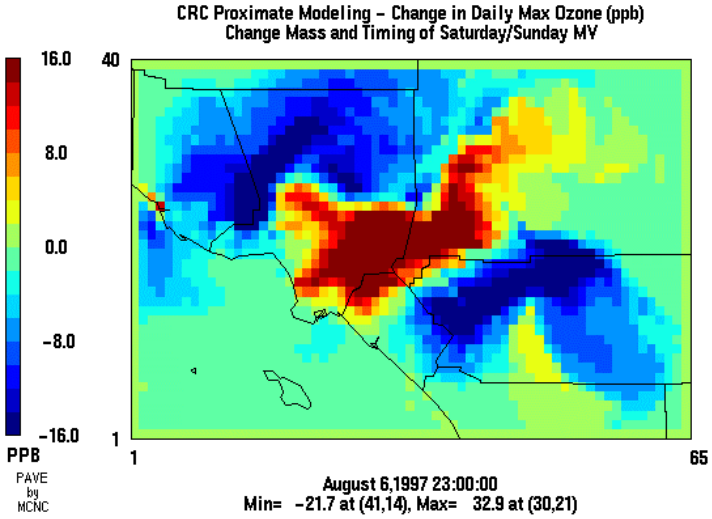
CB4 – Change MV – Saturday Impact (run=h2c)



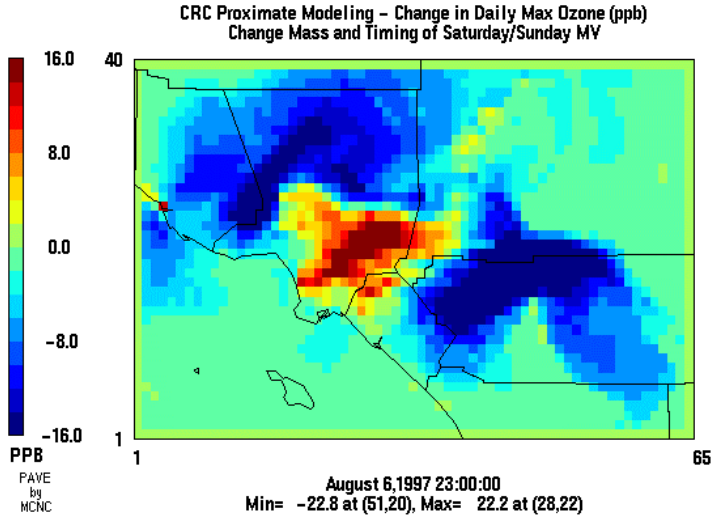
SAP99 – Change MV – Saturday Impact (run=h2d)



CB4 – Change MV – Sunday Impact (run=h2c)



SAP99 – Change MV – Sunday Impact (run=h2d)



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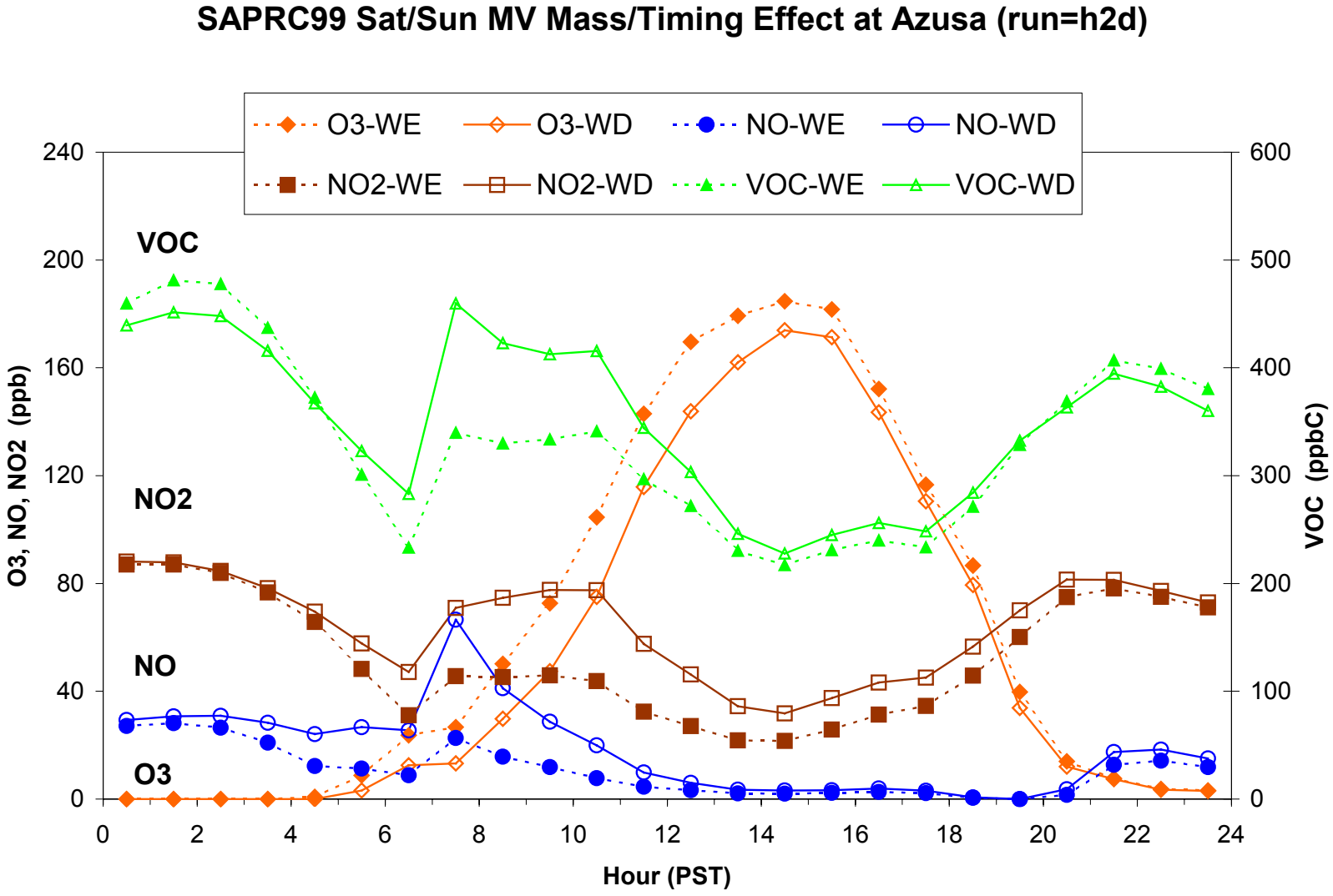
SAPRC99 Weekend Effect for Azusa



SAPRC99 Findings

- Substantially higher ozone than CB4
- Poor base case model performance
- Response to weekend MV emission changes in poorer agreement with observations for downwind locations
- Response to weekend MV emission changes consistent with observations at Azusa
- SAPRC99 might perform well with different base emissions , e.g., less VOCs or more NOx

Conclusions on the Weekend Effect for Ozone

Proximate modeling results are consistent with the following conclusions

- **Changes to the mass of onroad MV emissions on weekend days are the main cause of the weekend effect**
- **Changes to the spatial distribution of MV emissions on the weekend could contribute**
- **Weekend ozone is relatively insensitive to changes in the timing of MV emissions**

Conclusions on the Weekend Effect for Ozone

(concluded)

- There is little carryover of effects from one weekend day to the next
- Changes in photolysis rates due to changes in aerosol load are not the cause of the weekend effect
- Based on the projected 2010 emissions in the current AQMP, the weekend effect for ozone will decrease in magnitude and extent by 2010